incomplete on this side); *f*, an opening in the fan, left between two diverging ribs. From a photograph.

Fig. 2. Section across the base of fig. 1 (magnified about 50 diameters).
Fig. 3. Large acuate of the intermediate layer.
Fig. 4. Dumbbell-like spicule of the base or axis.
Fig. 5. Spined echinating acuate.
Fig. 6. Needle-like spicule of the dermal layer. The head is a little too inflated to be normal.
Fig. 7. Equianchorate and tricurvate spicules of the sarcode.

Figs. 3–7 all magnified 140 diameters.

PLATE VII.

Varieties of the spicules of *P. plena.*

Fig. 8. Common variety of the large acuate, with a spinose head.
Fig. 9. Common variety of the large acuate with the distal end rounded off.
Fig. 10. A similar but extremely stunted form.
Fig. 11. A variety intermediate between those of figs. 9, 10.
Fig. 12. A young form of the large acuate, with spined head.
Fig. 13. A nearly spineless variety of the echinating acuate.
Fig. 14. Similar, but with a larger number of spines.
Fig. 15. Spined acuate, bent abruptly to one side.

Figs. 8–15 are all magnified 140 diameters.

Figs. 16, 17. Normal forms of spined echinating acuates (× 435).
Fig. 18. Large smooth acuate, bent upon itself hook-like (× 140).
Fig. 19. Flesh-spicules. *a*, equianchorates; *b*, tricurvates. × 435.
Fig. 20. Dermal spicule with both ends inflated and microspined (× 435).
Fig. 21. Short stout form of axial or dumbbell spicule.
Fig. 22. Attenuated form of the same spicule.
Fig. 23. Same kind of spicule bent upon itself at right angles.
Fig. 24. Same spicule, doubly inflated at one end.
Fig. 25. Same spicule, with one end rounded off and produced into a blunt mucrone.
Fig. 26. Similar, but without the mucrone.

Figs. 21–26 all magnified 140 diameters.

Fig. 27. Head of a dermal spicule, magnified 435 diameters, to show the minute spines.
Fig. 28. Ordinary dermal needle (× 140).
Fig. 29. Normal dumbbell form (× 435).

V.—*On the Occurrence in North America of rare Extinct Vertebrates found fragmentarily in England.*—No. 2. By Prof. R. OWEN, C.B., F.R.S., &c.

[Plate VIII.]

[Continued from ser. 5, vol. ii. p. 223.]

Part III. RESTORATION OF *LEIODON ANCEPS.*

IN the section on Mosasauroids, in the "Report on British

Fossil Reptiles" for 1841*, a genus *Leiodon* was defined on a modification of mosasauroid teeth in a fragment of jaw discovered in a Cretaceous formation in Norfolk, and figured in plate lxxii. figs. 1, 2, of my 'Odontography.'

Certain vertebræ from the Greensand of New Jersey, North America, submitted to my examination by Prof. Henry Rogers, in 1849†, presented mosasauroid characters, but differed from those which had been referred by Cuvier‡ and Goldfuss§ to the type genus *Mosasaurus* in a degree which led me to remark that "they might belong to the genus *Leiodon*;" but I, provisionally, described and figured them under the name of "*Macrosaurus lævis*." Similar vertebræ were subsequently discovered by Prof. Emmons in Cretaceous deposits of North Carolina, and were referred by him to the genus *Macrosaurus*‖.

Dr. Joseph Leidy, in his excellent work 'On the Cretaceous Reptiles of the United States,' 4to, 1864, notices mosasauroid teeth from other localities in the United States, several of which he states to "correspond in all anatomical characters with the teeth described by Prof. Owen as characteristic of a distinct genus, to which he has given the name of *Leiodon*"¶; but in the figures of his plate xi. those teeth are referred to *Mosasaurus*.

Prof. E. D. Cope, in his richly illustrated volume on the Vertebrata of the Cretaceous Formations of the West, describes and figures specimens which enabled him to show that the vertebræ of *Macrosaurus* were actually those of *Leiodon lævis*, and also to define other species of that mosasauroid genus** obtained from the "Kansas chalk."

Finally, in the 'Transactions of the Kansas Academy of Science' for 1877–8, vol. vi., Prof. F. H. Snow describes and figures characteristic portions of an almost entire skeleton of a *Leiodon* which he had the good fortune to expose in the

* Report of the British Association for the Advancement of Science for 1841, 8vo, p. 144.

† Quarterly Journal of the Geological Society of London, vol. v. (1849), p. 380, pl. v.

‡ Recherches sur les Ossemens Fossiles, 4to, 1824, tome v. 2e partie, p. 310.

§ Nov. Act. Acad. Nat.-Cur. vol. xxi. p. 179 (1845).

‖ Report on the Geology of North Carolina, 1858, p. 213, fig. 34, *a*.

¶ Smithsonian Contributions to Knowledge, vol. *ut suprà*, p. 130.

** "Several names have been proposed for our species, the earliest of which is *Macrosaurus*, Owen. This name applies to species with compressed dorsal vertebræ, as *L. lævis* and *L. Mitchellii*, both from New Jersey Greensand."—Section "Leiodon, Owen," *op. cit.* 4to, 1875, pp. 160, 161, pls. xxviii.-xxxiii.

"yellow limestones belonging to the Niobrara group of the Cretaceous Formations"*.

From these American materials a restoration of the *Leiodon* modification of the Mosasauroid Lacertians may be undertaken. Of the skull I have little to add to the description given in my paper "On the Rank and Affinities of the Mosasauroids"†. The edentulous production of the premaxillary (Pl. VIII. fig. 1, *a*) beyond the alveoli of the $\frac{2-2}{}$ incisors may be noticed as suggestive of a rudiment or beginning of the Ziphioid modification of the cetaceous cranium. The mandible is slender, with a low coronoid process and slightly produced angle. A specimen has been found 26 inches in length‡.

The vertebral column of *Leiodon anceps* (Pl. VIII. fig. 1) exhibits the range of modification in its several regions characteristic of these great extinct 'Lacertia Natantia'§, and contrasting with the comparative uniformity of the vertebræ in *Python* and other Ophidia.

The atlas (ib. fig. 2) consists, as in lizards‖, of a pair of neurapophyses, *n*, and a detached hæmapophysis, *h*, simulating a centrum¶. The transverse exceeds the vertical diameter, although the latter is extended by a short obtuse hypapophysial spine, *y*, less developed than in *Mosasaurus***. Each neurapophysis presents a large subconcave facet for articulating with part of the occipital condyle; a rudimental diapophysis projects from the outer side.

The axis (ib. fig. 3) consists of a long body, including the proper centrum of the atlas, *c a*, coalesced with that of the axis, *c x*. The latter develops a hypapophysis, *y*, to which is articulated a short hæmapophysis, *h*. A compressed vertical ridge-like process (par-diapophysis, *d*) extends from each side of the centrum; it may be for the support of a rudimental cervical rib.

A few of the succeeding vertebræ are characterized by both diapophysis (ib. fig. 4, *d*) and hypapophysis, *y*—the latter with a rough articular surface for ligamentous attachment of a

* *Op. cit.* p. 54, plate opposite same page, and woodcut p. 57.

† Quarterly Journal of the Geological Society, vol. xxxiii. p. 695, fig. 15.

‡ In the grey shale of the Niobraska chalk; referred by Prof. Cope to a *Leiodon nepæolicus* (*op. cit.* p. 177).

§ 'Fossil Reptilia of the Cretaceous Formations,' 4to, 1851, p. 29.

‖ Cuv. Oss. Foss. 4to, vol. v. pl. xvii. fig. 10.

¶ See 'Annals and Magazine of Natural History,' vol. xx. p. 217, figs. 4, 5.

** Cuv. *op. cit.* pl. xx. fig. 14, *c* (after Camper).

short imperforate hæmapophysis, *h*. The series of these hæmapophyses are homologues of those described by Sir Philip de M. Grey Egerton under the name of "subvertebral wedge-bones" in *Ichthyosaurus**. They are present in similar intervertebral position in *Amblyrhynchus*†, where they are five or six in number. They are represented by confluent pieces in *Cyclodus*‡. But the presence of hypapophyses for their support distinguishes the Mosasauroid from other families of Lacertilia as well as from both Ichthyo- and Sauropterygia.

The diapophysis of the third cervical supports a rib; and a similar costigerous process§ is present in the dorsal vertebræ. This series may be conveniently, though artificially, defined by the suppression of the hypapophysis. The zygapophyses (figs. 5 and 6, *z*, *z'*) disappear in the posterior dorsals as in fig. 7. The diminution in vertical and increase in longitudinal extent, together with its descent in position from the side of the centrum, reduce the "transverse process" to a "parapophysis," *p*, fig. 8, which characterizes the lumbar vertebræ. This change is attended with a modification of the shape of the centrum, the transverse section of which becomes triangular with the base downward, instead of the elliptic shape shown in the vertebræ from the antecedent part of the column. There is no sacrum by ankylosis: a single vertebra supports a pair of small rib-like, feebly curved, iliac bones (ib. fig. 1, *l*), with a slightly expanded, distal, bifaceted, syndesmosal surface, the larger division for the ischium. The pubics, *u*, have a smaller syndesmosal terminal expansion, are slender and nearly straight. The ischia (*m*) are broader, have a short posterior process, offer proximally a syndesmosal surface divided between the ilium and the femur, and have a distal surface for a symphysis with their fellow, completing the inverted arch below.

The anterior caudal vertebræ add to the parapophyses (fig. 9, *p*) a pair of hypapophyses, *y*, to which is articulated a hæmal arch formed by the apical confluence of a pair of hæmapophyses, *h*, from which confluence extends obliquely backward a hæmal spine, *h s*, rivalling or surpassing the neural one, *n s*, in length. The parapophysis gradually shortens and disappears at about the anterior third of the tail (fig. 10), which thereafter shows its natatory compression and

* Trans. Geol. Soc. ser. 2, vol. v. p. 187, pl. 14 (1836).
† Ann. & Mag. Nat. Hist. *ut suprà*, fig. 4, p. 221.
‡ Ib. ib. fig. 5, p. 223.
§ This, though marked *d*, combines the origins of both *di-* and *par-apophyses*; in fig. 8 it becomes *p*.

vertical extension attended with piscine confluence of the hæm- (*h*) with the hyp- (*y*) apophyses (ib. fig. 11).

No Mosasauroid has hitherto been discovered so entire and undisturbed, or exhumed with such exact care, as to yield a precise numerical vertebral formula. Even in the skeleton of the *Leiodon* described by Prof. Snow, "only two of the twenty vertebræ, which were scattered over the slab in all positions, remained united"*.

The nearest approaches to the true number in the genus *Mosasaurus* I believe to have been made by Cuvier (who assigns 133) and by Goldfuss (157). Of *Leiodon* I estimate, provisionally, from the various data at command, the following:—

	Number.
Atlas and axis	2
Vertebræ (type 4) with hæmapophysis, hypapophysis, diapophysis, and zygapophysis	5
„ (type 5) with hypapophysis, zygapophysis, and diapophysis	7
„ (type 6) with zygapophysis and diapophysis	18
„ (type 7) with diapophysis	22
„ (type 8) with parapophysis	15
„ (type 9) with parapophysis and unankylosed hæmal arch	24
„ (type 10) with unankylosed hæmal arch	14
„ (type 11) with ankylosed hæmal arch †	44
„ (type 12) with centrum and neurapophyses rudimental or none	7
	158

The vertebræ of *Leiodon* are devoid of the accessory zygantral and zygosphenal articulations.

All the ribs or pleurapophyses, where present or preserved, are monocipital.

In entering upon the description of the British Fossil Reptilia ‡ I found the descriptive phrases applied in Anthropotomy to the parts and processes of the vertebræ cumbrous, if at all applicable to the homologous parts in those of the lower (especially the cold-blooded) Vertebrates, some apophyses in which had no homologues in the human vertebræ. I therefore proposed a "Nomenclature," substituting "names" for "phrases," and devised names for parts which previously had none.

* *Op. cit.* p. 57.

† All the above have the centrum (*c*) and ankylosed neural arch and spine (*n s*).

‡ "On the *Plesiosaurus macrocephalus*," Trans. Geol. Soc. vol. v. ser. 2, p. 515 (1838); "Reports on British Fossil Reptiles," in Transactions of the British Association for 1840 and 1841.

The general adaptive characters of the Mosasaurian vertebræ relate to aquatic life; and in the category (type 7) in which the zygapophyses disappear, not to return, there is a significant indication of a tendency towards the Cetacea; in a great extent of the caudal series (type 11) a piscine character prevails. Both these modifications are engrafted on, or associated with, the lacertian type of the procœlian vertebra.

The movements of this gigantic reptile among the sea-waves, mainly executed by the long and flexile vertebral column, were guided or modified by the action of both pectoral and pelvic fins: the retention of both pairs is more piscine than cetacean; or, we may say, the common vertebrate number of limbs, in Mosasaurs as in Ichthyosaurs, has not been departed from, as in some later and more modified forms of warm-blooded marine Vertebrates. Are the pelvic and femoral rudiments, which are concealed beneath the skin in modern whales, the remnants of the ventral fins of the cold-blooded marine air-breather? or are they remnants of the hind legs of a warm-blooded, ancestral, shore-haunting quadruped? Such pleasant speculations as a solace to the work of acquisition of positive facts may be condoned.

The framework of the pectoral fin was first restored by Prof. Marsh *, in the American Mosasauroid which he calls *Lestosaurus simus* (*Platecarpus*, Cope): the Lacertian type of this framework is illustrated, in comparison with the Cetacean and Enaliosaurian types, in the undercited work †. In the large proportion of a *Leiodon* discovered by Prof. Snow of the Kansas University, in the "yellow limestones along the Hackbury Creek, in Yove County, Kansas," the framework of the pectoral fin was found "lying underneath the ribs and vertebræ, with the bones in natural position." Fig. 13, Pl. VIII., is a reduced copy of the Professor's figure of this fin ‡. Assuming the accuracy of the arrangement of the bones, the first (innermost or radial) digit (I) is the longest, and includes a metacarpal (*m*) and eleven phalanges; the second digit (II) has the same number of phalanges and nearly the same length; the third (III) has nine phalanges; the fourth (IV) shows seven, but one or two small terminal bones seem to be wanting; the fifth, outermost or ulnar, digit (V) has evidently been the shortest, and retains but five phalanges. In the general shape of

* American Journal of Science and Arts, vol. iii. p. 4, pl. x. (1872).

† Quarterly Journal of the Geological Society, vol. xxxiv. p. 748, figs. 1–4 (1878).

‡ Transactions of the Kansas Academy of Sciences, vol. vi. p. 57, (1878). This volume had not appeared at the date of the reading of my second paper, "On the Affinities of the Mosasauridæ," June 5, 1878.

the fin, decreasing in length from the radial, 54, to the ulnar, 55, side, the fin of *Leiodon* resembles more that of the Cetacean* than does the fin of *Lestosaurus*, but with the marked difference of the first digit being the shortest in Cetacea and the longest in the present genus of Mosasauria.

The most instructive addition to the anatomy of this extinct family of marine Saurians is the degree in which the dermal skeleton is preserved in the Kansas example of *Leiodon* †.

Prof. Marsh had referred certain dermal scutes to Mosasauroid reptiles, and conceived them "to be mainly from the lower part of the neck." "In the genus *Liodon*," he adds, "the scutes are also imbricate, and somewhat similar to those above described" ‡ (in the genus *Edestosaurus*). But Prof. Snow has brought to light an extensive series of such osseous scales, indicative of a more general dermal scutation. Fig. 14, Pl. VIII., is a copy of a portion of this armour from one of the flanks of the *Leiodon*, of the natural size. In no known Ophidian are the scales formed in any proportion by bone; the purely epidermal tissue of their exuvial coat would be wholly dissolved in remains from a Cretaceous matrix, or, indeed, of one of more recent date. The Sheppey and other Eocene serpents are represented only by the parts of their endoskeleton; and so large a proportion of this has been found in natural articulation as to lend ground for expectation that the dermal scales would have been preserved if, as in lizards, they had included petrifiable parts §. In the existing members of the Lacertian order bone is developed at the base of the scale in several genera, e. g. *Trachysaurus*, *Tribolonotus*, *Ophisaurus*, &c. And if the curious fossils called "granicones," found in the "Feather-bed" shales of the Middle Purbecks, have been rightly interpreted ||, they likewise exemplify the osseous supports of the scales of an extinct lizard (*Nuthetes destructor*)—and, by virtue of their tissue, have been susceptible of fossilization, and testify to the dermal character of that species.

The formal character of both maxillary and mandibular

* Quart. Journ. Geol. Soc. vol. xxxiv. p. 749, fig. 1.

† "On the Dermal Covering of a Mosasauroid Reptile (*Liodon dyspelor*, Cope)," by Prof. F. H. Snow, *op. cit.* p. 54. The figure occupies p. 55.

‡ 'American Journal of Science and Arts,' vol. iii. p. 11 (April 1872).

§ Owen, 'History of British Fossil Reptiles,' 4to, p. 146, pl. *Ophidians*, 4. I have lately been favoured, by Mr. Shrubsole of Sheerness, with an opportunity of examining a greater extent of the vertebral column of *Palæophis toliapicus* than the subject of my plate, but unaccompanied by any trace of scutes.

|| Transactions of the Royal Microscopical Society, vol. i. p. 233, pl. xii. (1878).

teeth, attributed to the genus *Leiodon* and exemplified by transverse sections in fig. 15, Pl. VIII., has been found constant and characteristic of those teeth in the species of the genus noted as from the various localities in Leidy's 'Monograph on the Cretaceous Reptiles of the United States,' and represented in pls. ix.–xi., and in the woodcuts of pp. 58–69. The subject of Leidy's cut no. 18, and of fig. 7, pl. ix., from Monmouth County, New Jersey, is noted as corresponding in all its anatomical characters with those of *Leiodon* (p. 62).

The Mosasauroid or family characters of the teeth are strictly retained. The crown, composed of hard dentine with a thin coat of enamel, is supported by, and as it were wedged into a basis (fang or root) of the modified osteine called "cement." This is much thicker than the crown, and presents a rounded or full elliptical transverse section, whatever be the shape of the crown (compare the outline *a* (root) with *b* (crown) of a tooth of *Leiodon*, fig. 15, Pl. VIII.).

The root, when first formed, is implanted in a distinct socket, and the "thecodont" type of dentition is manifested. But this is a transitory condition; the cement becoming confluent with the bone of the socket, and, partially rising above the alveolar border of the jaw, the tooth then exhibits the "acrodont" type. But a much larger proportion of the orginal and independent tooth can be traced in the substance of the jaw than is the case in the existing acrodont Lacertilia. The pulp-cavity remains in the basal half of the crown, and descends a short way into the cemental fang, where it is closed by a coarser and more vascular modification of the cement. The vertical or longitudinal extent of the enamelled crown at its outer and exposed surface is about one third that of the fang.

The teeth are displaced and succeeded by others, many times during the life of the individual, as in modern Lacertilia. At least I have met with no specimens in which a reserve cavity with a more or less advanced successional tooth has not existed at the postero-internal side of the implanted base of the functional tooth*. The germ of a third generation in the form of the enamelled apex of the crown may be detected within the pulp-cavity of the second, which is in course of succeeding and displacing the first or fully formed tooth †.

The nearest resemblance to the Mosasauroid type of tooth is now presented by certain Cetacea, as, *e. g.*, the Cachalots ‡, Platanists §, and more especially by the Ziphioids, in which

* 'Odontography,' p. 259, pl. 72. fig. 2.
† See Leidy, *ut suprà*, pl. xi. fig. 4, *d*.
‡ 'Odontography,' pl. 89. fig. 2. § Ib. pl. 87 *a*.

the enamelled crown is borne upon an enormously developed cemental root, to which conical mass it sometimes appears as a mere apex*.

EXPLANATION OF PLATE VIII.

Fig. 1. Restoration of *Leiodon anceps*, Ow., as shown by an outline of the skeleton, omitting certain of the estimated numbers of the constituent types of vertebræ, for lack of space.
Fig. 2. Side view of atlas vertebra.
Fig. 3. „ axis vertebra.
Fig. 4. „ cervical vertebra.
Fig. 5. „ dorsal vertebra (first type).
Fig. 6. „ dorsal vertebra (second type).
Fig. 7. „ dorsal vertebra (third type).
Fig. 8. „ lumbar vertebra.
Fig. 9. Front view of caudal vertebra (first type).
Fig. 10. Side view of caudal vertebra (second type).
Fig. 11. Front view of caudal vertebra (third type).
Fig. 12. „ terminal caudal vertebra.
Fig. 13. Bones of right antebrachium and fin.
Fig. 14. Portion of dermal scutation of the side of the trunk.
Fig. 15. Outline of transverse sections of maxillary tooth. *a*, root; *b*, crown.

(All the figures, save 14 and 15, are much reduced in size.)

VI.—*Studies on Fossil Sponges.*—V. *Calcispongiæ.* By Karl Alfred Zittel.

[Continued from vol. iii. p. 379.]

Revision of the Fossil Calcispongiæ.

Family 1. **Ascones**, Häckel.

Stomach-wall thin, penetrated by inconstant cutaneous pores, wall-less and temporary openings in the parenchyma. Skeletal spicules usually in a single layer parallel to the surface.

No fossil representatives at present known.

Family 2. **Leucones.**

Stomach-wall thick, irregularly traversed by curved, branched, usually anastomosing canals, running without any definite arrangement. Parenchyma-skeleton consisting of

* See 'Monograph on British Fossil Cetacea,' p. 12, pl. 1. fig. 5, *a*, in the volume (4to) of the Palæontographical Society issued in 1870.